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Environmental effects of the September 2018 Mw 7.5 Palu (Sulawesi Island, Indonesia) earthquake and building damage induced by the earthquake and the subsequent tsunami and liquefaction phenomena

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On September 28, 2018, an Mw 7.5 earthquake occurred in the central-western Sulawesi Island (Indonesia) with focal depth of 10 km. Its epicenter was on the coastal Lende area, 61 km north of Palu city. The Palu-Koro fault, one of the most prominent active fault of Sulawesi, was the causative structure.
The surface ruptures directed parallel and in an en echelon arrangement to the Palu-Koro fault and resulted in damage to roads and buildings revealing left lateral offset coinciding with the causative fault.
The tsunami devastated Talise beach in Palu city, Dongala village at the western tip of Palu bay as well as all many villages along the coast of Palu bay resulting in thousands fatalities. t is attributed to the synergy of coseismic seabed displacement, submarine landslides and liquefied gravity flow within Palu bay.
Liquefaction phenomena occurred in Balaroa and Petobo districts in central Palu and along a riverbed located SE of Palu. They comprised liquefaction- and lateral spreading-initiated flow and caused total destruction of the aforementioned neighborhoods, which were swallowed up in a mud wave.
The ground cracks were observed as tension cracks close to sites with gravitational movements and lateral spreading.
As regards, the impact on the building stock, the earthquake caused non-structural and structural damage mainly in Palu city. Multistory reinforced concrete (R/C) hotels and malls suffered heavy structural damage resulting in partial or total collapse. The ground floor of the buildings collapsed, while the upper floors behaved as rigid bodies, resulting in toppling of the damaged structures. In contrast, wooden and steel-frame buildings suffered mainly non-structural damage by the earthquake ground motion. Severe structural damage were observed in monumental structures such as mosques.
In the liquefaction-affected areas, the level of destruction was almost complete with many buildings of all types being compressed together and wrecked into a soil and debris zone resulting in significant loss of life.
In the tsunami affected areas, all wooden structures founded along the sea front were totally washed away by the wave pressure and only their concrete foundations were left in place. In villages along the western coast of Palu bay, some wooden structures with wooden foundation were detached from their foundations but not destroyed.
The R/C buildings suffered typical tsunami-induced damage in the ground floor and in the first floor due to tsunami water pressure and impact with floating debris. Punching failure of brick infill walls under out-of-plane tsunami pressures were observed in the form of large circular openings in infill walls. Flexural failures of columns within their midheights are attributed to impact forces generated by floating debris.
The Integrated Tsunami Intensity Scale (ITIS-2012) is applied for the Palu tsunami based on our field survey on the tsunami affected area and on all already published official reports on the tsunami impact. Tsunami quantities and the impact on mobile objects, on coastal infrastructure, on the environment and on buildings were taken into account for the estimation of intensities. The maximum assigned intensities is XII.